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Extrafloral nectaries on bamboo culm sheath auricles: Observations on four Southeast Asian giant bamboo species (*Poaceae : Bambusoideae*)

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Summary. The presence of ants and other insects on the auricles of bamboo species have led various authors to presume the existence of extrafloral nectaries in these structures. In this study we tested the auricles of four bamboo species in Peninsular Malaysia, *Gigantochloa scortechinii*, *G. thoii*, *Dendrocalamus pendulus* and *Schizostachyum zollingeri*, for the secretion of sugar. One species, *G. scortechinii*, was additionally tested for protein secretion. Our results confirmed that the auricles of these bamboo species are functional extrafloral nectaries. Observations of the transition of the auricles from culm sheath to leaf sheath are also given. The organisms encountered on the culm sheath auricles of the four bamboo species are listed. It is not known whether species without, or with inconspicuous, auricles also produce extrafloral nectar elsewhere.

The presence of extrafloral nectaries in many plant species of tropical forests is a well-known phenomenon (Fiala & Linsenmair 1995, Oliveira & Oliveira-Filho 1991, Koptur 1992). Recently, various authors have also reported the visit of different ant species and members of other insect taxa on bamboo culm-sheath auricles (Fig. 1) and leaf-sheath auricles (Fig. 2) (Maschwitz *et al.* 1986, Maschwitz *et al.*1987, Callaghan 1992, Dransfield 1992, Kovac 1994). Also, Maschwitz *et al.* (1986) described how the larvae of the tortricid *Semutophila saccharopa* (*Lepidoptera: Tortricidae*) spun silk sheaths above or beside the leaf-sheath auricles of *Gigantochloa scortechinii*. These larvae form trophobioses with various ant species and feed on plant tissue and the extrafloral nectar that presumably was secreted by nectar glands on the auricles (Maschwitz *et al.* 1986, Maschwitz, unpublished observation).

Trophobiosis of coreid bugs of the genera *Cloresmus* and *Notobitus* with several ant species on bamboo is also reported in Maschwitz *et al.* (1987); these bugs were also observed feeding from the bamboo auricles (Maschwitz *et al.* 1987, Maschwitz, unpublished observation). The production of extrafloral nectar in these structures (Maschwitz *et al.* 1987, Callaghan 1992,

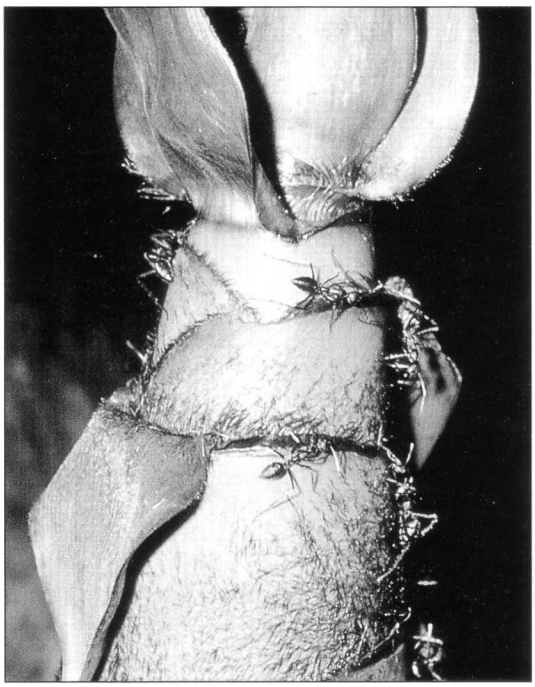
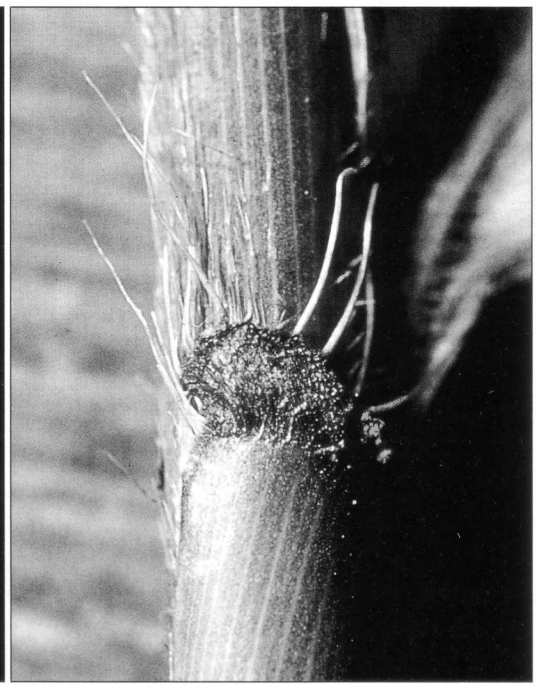

Fig. 1 (left). Culm-sheath auricle of *Gigantochloa scortechinii* visited by *Camponotus auriventris* (Formicidae, Formicinae). Photo: A.L. Schellerich-Kaaden. **Fig. 2** (right). Leaf-sheath auricle of *G. thoii.* (Photo: A.L. Schellerich-Kaaden)

Kovac 1994) was presumed by all these authors but not verified yet. Furthermore, the literature concerning ant-plant relationships, extrafloral nectaries (often abbreviated as EFN) and bamboo systematics examined so far did not mention the presence of extrafloral nectaries in Southeast Asian bamboos (Holttum 1958, Bentley & Elias 1983, Beattie 1985, Widjaja 1987, Oliveira & Oliveira-Filho 1991, Koptur 1992, Dransfield, 1992, Wong 1992, 1995a, 1995b). Therefore, observations related to this were also made during a survey of the ant diversity of the bamboo crown region (Schellerich-Kaaden *et al.*, unpublished results).

METHODOLOGY

Our investigation was carried out in the vicinity of the Gombak Field Studies Centre of the University of Malaya (about 30 km northeast of Kuala Lumpur, 240–500 m a.s.l.). The area is covered by secondary forest with a number of bamboo-dominated sites. Several bamboo species are found there, the dominant species being *Gigantochloa scortechinii* (Bishop 1973). From July to September 1993 during the active bamboo-growing season, we tested the sheath auricles on shoots of four bamboo species, *G. scortechinii*, *G. thoii*, *Dendrocalamus pendulus* and *Schizostachyum zollingeri* for the secretion of sugar (Tables 1, 2). *G. scortechinii* was additionally tested for the secretion of proteins (Tables 1, 2). The tests were performed with Dextrostix (Merck) and Albustix (Merck). Shoots of all four bamboo species were repeatedly checked for the presence of ants, other insects (Table 3), growth and secretion. The majority

Table 1. Results of the tests for sugar secretion with Dextrostix (Merck) on culm-sheath auricles of four bamboo species, *Gigantochloa scortechinii*, *Gigantochloa thoii*, *Dendrocalamus pendulus* and *Schizostachyum zollingeri*; and for protein secretion with Albustix (Merck) on auricles of *Gigantochloa scortechinii*. Negative results were often associated with a lack of moisture or liquids on the auricles.

Reaction of Dextrostix	***G. scortechinii***	***G. thoii***	***D. pendulus***	***S. zollingeri***
positive	56	19	18	4
negative	17	7	0	0
indistinct	2	0	1	1
total n	75	26	19	5
Reaction of Albustix				
positive	13			
negative	1			
indistinct	2			
total n	16			

Table 2. Amount of glucose measured with Dextrostix (Merck) on culm-sheath auricles of *Gigantochloa scortechinii*, *G. thoii*, *Dendrocalamus pendulus* and *Schizostachyum zollingeri*; and of protein measured with Albustix (Merck) on auricles of *Gigantochloa scortechinii*.

g/l sugar	***G. scortechinii***	***G. thoii***	***D. pendulus***	***S. zollingeri***
+*	4	2	1	0
0.45–0.90	11	4	8	1
0.90–1.30	16	7	3	1
1.30–1.75	10	3	3	0
1.75–2.50	3	0	1	1
max**	12	3	2	1
g/l protein				
15–20	8			
30	3			
100		2		

* A colour-reaction was visible but it did not correspond with the colour representative of the range 0.45–0.90 g/l.

** Maximum coloration of Dextrostix at 250 mg glucose/100 ml.

Table 3. Ant species (genera) and other insect taxa encountered on the culm-sheath auricles of *Gigantochloa scortechinii*, *G. thoii*, *Dendrocalamus pendulus* and *Schizostachyum zollingeri*.

Ant species and genera	Other insect taxa
Diacamma sp.	Dermaptera
Odontomachus sp.	Homoptera
Crematogaster spp.	*Auchenorrhyncha*
Pheidole spp.	Heteroptera
Myrmicaria sp.	Coleoptera: Curculionidae
Meranoplus mucronatus	Diptera: a.o. Culicidae
Cataulacus sp.	Lepidoptera: a.o. Tortricidae
Technomyrmex sp.	Hymenoptera: Meliponinae
Dolichoderus sp.	
Polyrhachis sp.	
Camponotus auriventris	
Camponotus spp.	
Oecophylla sp.	

(a.o. = among others.)

of the tests for sugar secretion, visitors and growth were made at different times throughout the day; only a small number of *G. scortechinii* auricles was also tested at night (test for sugar secretion n = 4, test for visitors n = 62). All tests for protein secretion were made during day time.

OBSERVATIONS AND DISCUSSION

Our results show that the auricles of all four bamboo species investigated (belonging to three genera) secrete sugar in various concentrations (Table 2), and 72–95% of the tests were positive (Table 1). For *Gigantochloa scortechinii* we could ascertain the secretion of small amounts of protein (Table 1, 2). Negative results were often obtained when there was a lack of moisture on the auricles.

Like the authors cited above we observed various ant species and other insect species on the auricles of the four bamboo species (Table 3). Among these, the totricid larvae reported by Maschwitz *et al.* (1986), which were situated on the culm-sheath auricles or under the culm-sheath blades near to the auricles, were often visited by ants.

Our results confirm that the auricles of these bamboo species are functioning extrafloral nectaries. Although these structures are found in many bamboo species there are also bamboo

species which lack auricles, e.g., *Holttumochloa korbuensis*, *Dinochloa obclavata*, *D. robusta*, *Racemobambos pairinii*, and *Thyrsostachys siamensis* (Dransfield 1992, Wong 1995b). Many species have inconspicious auricles that can be very reduced in some cases, e.g., *Schizostachyum terminale*, *Bambusa multiplex*, *Chimonobambusa quadrangularis*, and *Dendrocalamus dumosus* (Dransfield 1992, Wong 1995b). It is uncertain whether in these species there are other structures that function as extrafloral nectaries.

On the bamboo species investigated in this study, which all have auricles, we could observe that in some cases the visiting ant species changed in a day-night rhythm, in other cases the same ant species was present both day and night. Often, the auricles were totally covered by ants or with carton, earth or bamboo hair structures (e.g., by *Camponotus* sp., *Pheidole* sp., *Technomyrmex* sp.) (Fig. 3). Sometimes, the whole shoot was covered with earth (e.g., by *Myrmicaria* sp.). This behaviour has been observed frequently by the authors and is interpreted as a form of monopolization of a transitory available source of nutrition.

The EFNs in the growing apical region of the young culm show the longest activity, whereas those at the ground level cease to produce nectar after the internodes are grown to full length (Kovac 1994, Schellerich unpublished observation). This phenomenon is characteristic of many extrafloral nectaries. The production of nectar is mostly restricted to periods of shoot growth and leaf expansion (Beattie 1985 and references therein).

Fig. 3. Shoot of *Gigantochloa scortechinii* with auricles and connecting parts covered with earth by a *Camponotus* sp. (Formicidae, Formicinae). (Photo: A. L. Schellerich-Kaaden)

The culm sheaths are generally regarded as modified leaves which consist of the culm sheath proper and the culm-sheath blade (Holttum 1958, Dransfield 1992). The leaf sheaths resemble the culm sheaths but differ in coloration, size, degree of overlapping and in the leaf blade having a stalk. Both sheaths have the function to protect the developing internodes and buds and both bear auricles and ligules (Holttum 1958). In addition, there are branch and twig sheaths which also function in protection of the developing parts and can be seen as transitional states from culm sheath to leaf sheath. Considering these resemblances and the observations of ants on branch and leaf sheath auricles, it seemed logical to expect that these structures should also have extrafloral nectaries. Indeed, preliminary investigations with *G. scortechinii* branch and twig sheaths yielded positive reactions with Dextrostix and revealed that these structures were visited by ants.

In the transition from culm sheaths to leaf sheaths, the entire sheath structure diminishes in size and the auricles of the older leaf sheaths are either minute or absent. The same transition was observed in leafy branch shoots found developing from the base of the bamboo clump. Again the auricles yielded positive results when tested with Dextrostix and were visited by ants (Fig. 4). The leaf sheaths of older leaves mostly lacked or had no intact auricles and are, according to our observations, no more functioning as extrafloral nectaries. As such, active extrafloral nectaries appeared to be found mainly on the auricles of the sheaths covering the growing or younger branches and twigs.

Many studies conducted on different plants (e.g., Koptur 1992) showed that the ants attracted to such extrafloral nectaries also played a protective role. Whether this is true also in the case of extrafloral nectaries found in bamboo is now addressed by a separate study.

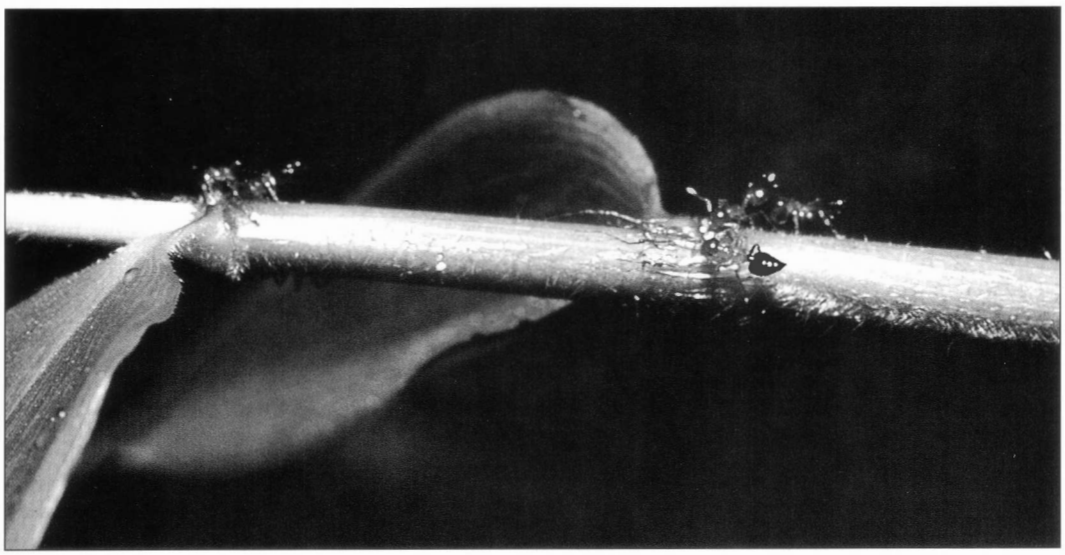

Fig. 4. Leafy branch of *G. scortechinii* with active extrafloral nectaries, visited by *Crematogaster* sp. (Photo: Jan Hopf & Swantje Stein)

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